CLIMATE RISK PROFILE SERIES

ADAPTING GREEN INNOVATION CENTRES TO CLIMATE CHANGE: ANALYSIS OF VALUE CHAIN ADAPTATION POTENTIAL

Wheat, faba beans, and honey value chains in Arsi Zone, **Ethiopia**

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CGIAR Research Program on Climate Change, Agriculture and Food Security CCAFS

ABOUT THIS REPORT

Climate change is affecting agriculture more than any other sector. Increased frequency and severity of drought, flood, heat, and unseasonable rainfall heavily impact rainfed agriculture, ultimately resulting in production losses. In that context, The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) through its climate action lever, are developing climate risk profiles for agricultural value chains in developing countries at the national and subnational level. These profiles build on past work conducted by CIAT and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)in collaboration with the World Bank and other partners, including FAO, USAID, DFID[1].

The present report aims to provide a climate and vulnerability analysis of the Green Innovation Centres (GIC) target commodity value chains. Herein we identify climate change- related vulnerabilities, hazards, and opportunities for adaptation to the same. Ultimately, our goal is to foster awareness of risks and adaptation priorities in the selected value chains and inform climate investments and planning through the recommendations on priority innovations to manage climate risks.

The report begins with an extensive literature reviews of the selected value chains and their key challenges and adaptation strategies. Climate hazards and crop suitability modelling offer insights into potential future scenarios under climate change. These results inform potential adaptation approaches, which are prioritized by in-country experts and stakeholders through an online survey. The top-rated adaptation priorities undergo a cost-benefit analysis. Finally, the results are peer-reviewed by the GIC country office and the Alliance scientific staff.

The **Green Innovation Centres** for the Agriculture and Food Sector (GIC) founded by German Federal Ministry for Economic Cooperation and Development (BMZ) and led by the German Agency for International Cooperation (GIZ) in collaboration with local ministries and programmes, aims to promote agricultural innovation under the *ONEWORLD No Hunger* initiative. Through the GIC, GIZ aims to generate employment raise farmers' income, and improve farmers' education and skills by funding training in good agricultural practices, water management, post-harvest processing, and entrepreneurship.

Planning, data collection and stakeholder engagement
- Literature review (key documents and datasets)

Climate risk assessment
- Hazard analysis
- Crop suitability modelling

Identification of adaptation strategies
- Detailed review
- Gap analysis and identification of climate adaptation
- Online survey
- CBA analysis

Production of the country climate profile and validation
- Peer-review

1 https://ccafs.cgiar.org/publications/csa-country-profiles

HIGHLIGHTS

- Agriculture is a key source of food, income, and employment in Arsi; it is also one of the most important sectors of the Ethiopian economy, contributing 36% of the national GDP and employing 60% of the population in Arsi **(Chapter 2, pg.8).**
- The agricultural sector is dominated by smallholder farmers working an average of 1.4 ha of land, and is characterized by sub-optimal input use, low mechanization, overreliance on rainfed agriculture, poor agricultural practices, and underdeveloped markets **(Chapter 2, pg. 9-10,14).**
- The federal government of Ethiopia has formulated several policies and strategies to support farmers in adapting to climate change and enhancing food security **(Chapter 3, pg. 15-16).**
- Successful implementation of these policies and strategies requires strengthening of institutional networks and capacity, and collaborative effort with other developmental agencies **(Chapter 3, pg.16).**
- Drought, heat stress, shortened growing seasons, and flash floods are the main climatic hazards likely to influence agricultural production in Arsi **(Chapter 5, pg. 19-20).**
- Key experts in Ethiopia highlighted that wheat and faba beans are highly affected by drought and a shorter rainy season, while honey is impacted by drought and high temperatures **(Chapter 5, pg. 25-26).**
- Farmers' own coping strategies include adjusting sowing dates, intercropping, planting trees, adopting some elements of soil and water conservation, crop and livestock integration, better weeding management techniques, and traditional control methods against honey and bee pests and predators **(Chapter 6, pg.27).**
- Conclusively the adaptation potential for the selected value chains is promising. However the cost-benefit analysis results indicate that the use of improved faba bean seed varieties is profitable with moderate risk of failure. There is a need for sufficient financial support due to the high implementation and maintenance costs **(Chapter 6, pg. 32-33).**

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ACRONYMS AND ABBREVIATIONS

ART	Alemayehu Row-seeding Technology
ATA	Agricultural Transformation Agency
CGIAR	Consortium of International Agricultural Research Centers
CIAT	International Center for Tropical Research
CSA	Central Statistics Agency
GDP	Gross domestic product
GIZ	German Agency for International Cooperation
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Center for Insect Physiology and Ecology
MEFCC	Ministry of Environment, Forest and Climate Change
MoANR	Ministry of Agriculture and Natural Resources
NARS	National Agricultural Research System
NGO	Non-governmental organization
PIF	Agricultural Policy Investment Framework
SNV	Netherlands Development Organization

1. INTRODUCTION

Agricultural production is a significant contributor to the Ethiopian economy and a source of livelihood for many rural households. The farming system in Ethiopia and in Arsi zone is mainly subsistence and is highly dependent on rainfall. In light of climate change and its adverse effects such as variability of rainfall, temperature, and drought, the agriculture sector has been hard hit. Future climatic predictions suggest that the trend will worsen in coming years. Nevertheless, the federal government has realized the need to empower farmers in order to enhance their resilience. In doing so, it has come up with several programs and policies to address climate change and other agricultural-sector challenges such as low soil fertility, low use of inputs, poverty, and weak market linkages. These goals feature in Ethiopia's Climate-Resilient Green Economy, Green Economy Strategy, implementation of the Growth and Transformation Plans phase II, and formation of the Agricultural Transformation Agency.

The government has partnered with several developmental agencies in transforming agricultural production, with the aim of enhancing food security and delivering a diversified and export-oriented agricultural sector. For example, the German Agency for International Cooperation (GIZ) in collaboration with the Ministry of Agriculture and Natural Resources and the Ethiopian Institute of Agricultural Research, is establishing Green Innovation Centres for the agriculture and food sector under the "ONEWORLD No Hunger" initiative, targeting the wheat, faba bean, and honey value chains in the highlands of the Arsi Zone in the Oromia Region (Figure 1).[2]

This document presents a climate and vulnerability analysis of the wheat, faba beans, and honey value chains in Arsi. It is aimed at informing stakeholders, policymakers, and the private sector about climate change risks and opportunities. It will also help in integrating climate change into the national development agenda. This climate risk profile is organized into six sections. The first describes the importance of agriculture to people's livelihoods in the four departments. Section two highlights the policies, strategies, and programs implemented in the three value chains that address climate change, while the third section discusses the governance and institutional resources and capacity. The fourth section discusses the main climatic hazards affecting the three value chains and presents climate modeling results for projected climatic change-related hazards and crop suitability maps. Additionally, it offers an analysis of vulnerabilities and risks posed by these hazards to the respective value chains. The ongoing on-farm adaptation strategies adopted by farmers to cope with these hazards as well as the cost benefit analysis results are discussed in the fifth section. The sixth section provides a synthesis and recommendations.

2 Green Innovation Centres are also implemented in other countries targeting different value chains: namely, Kenya, Zambia, Malawi, Mozambique, Cameroon, Togo, Nigeria, Ghana, Benin, Ivory Coast, Burkina Faso, Mali, Tunisia, India, and Vietnam.

Figure 1. Map of the selected region

Ethiopia is located in the Horn of Africa. The Arsi zone is located in the Central part of Ethiopia. Arsi is located in the southeast of the Oromia Region in Ethiopia. It covers around 19825.22km^2 and borders West Arsi to the west, West Hararge to the east, Bale to the southeast, and East Showa Zone in the northwest.

2. AGRICULTURAL CONTEXT

KEY MESSAGES

- Arsi is responsible for 15% of national wheat production and 10% of national bean production.
- Agriculture employs fully 80% of the Ethiopian taskforce and 56% of the rural population.
- Smallholder farmers dominate agricultural production in Arsi, with an average farm size of 1.4 ha.
- The main agricultural challenges in Arsi include overreliance on rainfed agriculture, poor agricultural practices, sub-optimal input use and mechanization, and poorly developed markets.

2.1. Economic relevance of farming

The agricultural sector remains critical, contributing 36% of the national gross domestic product (GDP) and employing nearly 80% of Ethiopia's workers and 56% of its rural population (National Planning Commission, 2017). In Oromia, 60% of the population works in agricultural production. Livestock is an important agricultural sub-sector; the main export products within the sub-sector are meat and hides and skins. Other important agricultural exports include coffee and pulses. Arsi lies within Ethiopia's wheat belt, and it is responsible for about 15% of the total wheat and 10% of the total faba bean production in the country. These statistics indicate Arsi's importance and potential for agricultural production.

Due to limited access to data at the zonal level, most of the data presented in the sub-sections below is provided at the level of the Oromia Region as a stand-in for the Arsi Zone.

2.2. People and livelihoods

The Ethiopian population is estimated at 94.351 million people. Arsi has a population of 3.459 million, the equivalent of approximately 4% of the country's population (CSA, 2013). In terms of gender distribution in Arsi, about 50.03% are women, and 49.97% men. Additionally, 86% of Arsi's population lives in rural areas, and their main economic activity is agricultural production. The agricultural sector employs 65% of Ethiopian women and 74% in rural areas (CSA, 2013).

Gender inequality remains a key issue in Ethiopia, whose gender inequality index is 0.499 (IMF, 2018). Gender inequality is also evident in the labour force and education sector. 77% of women are employed compared to 88% of men. In 2013, approximately 51% of the women in Ethiopia had never attended school compared to 32% of men, and 53% of the women in the Oromia Region specifically, compared to 32% of men (CSA, 2013). The disparity is even higher at 58% of women and 36% of men in rural areas of Oromia.

Access to potable water and electricity in Oromia stands at approximately 58% and 8% of the households, respectively. **Access to electricity is quite low in Oromia, with most households using kerosene for lighting and firewood and charcoal for cooking.** Only 0.3% of the households in Oromia are able to use electricity for cooking. This situation presents a burden to women and children because they are responsible for gathering firewood.

The rate of absolute poverty in Oromia stands at approximately 24%, which is an improvement from 45% in the early 1990s. 33% of the households suffer from food poverty, with the average household spending 52% of its income on the purchase of food (National Planning Commission, 2017). Furthermore, 37% and 11% of children below age 5 are stunted and wasted, respectively. **These statistics furnish evidence of food insecurity in Oromia and of the need to enhance agricultural productivity and household income to improve access to nutritional foods (Figure 2).**

2.3. Agricultural activities

About 42% of the total land area in Arsi is suitable for agricultural production, and 76% is used for production (CSA, 2016). The average farm size in the zone is 1.40 ha. Male landholders own 1.43 ha and female landholders 1.30 ha, and 119,124 women own land. The average size of landholdings in Arsi has been decreasing over time due to the rapidly growing population. Of the total landholders (593,609, an increase from 572,126 landholders in 2015), 573,898 owned their parcel, 121,192 rented, while the rest used other tenure systems (CSA, 2016). Among women landholders, approximately 97% owned their lands, 10% rented, and 6% used other tenure systems. As determined by land allocation, the most important agricultural activity in the area is crop production. The opposite is true of Ethiopia as a whole, where livestock is the primary agricultural sub-sector. Crop area in Arsi is approximately 1.09 ha per household, with the rest of the land used for grazing or left fallow or as woodland (CSA, 2016). Farmers within Arsi are mainly smallholders practicing subsistence farming, and a majority of the food produced is consumed within the household.

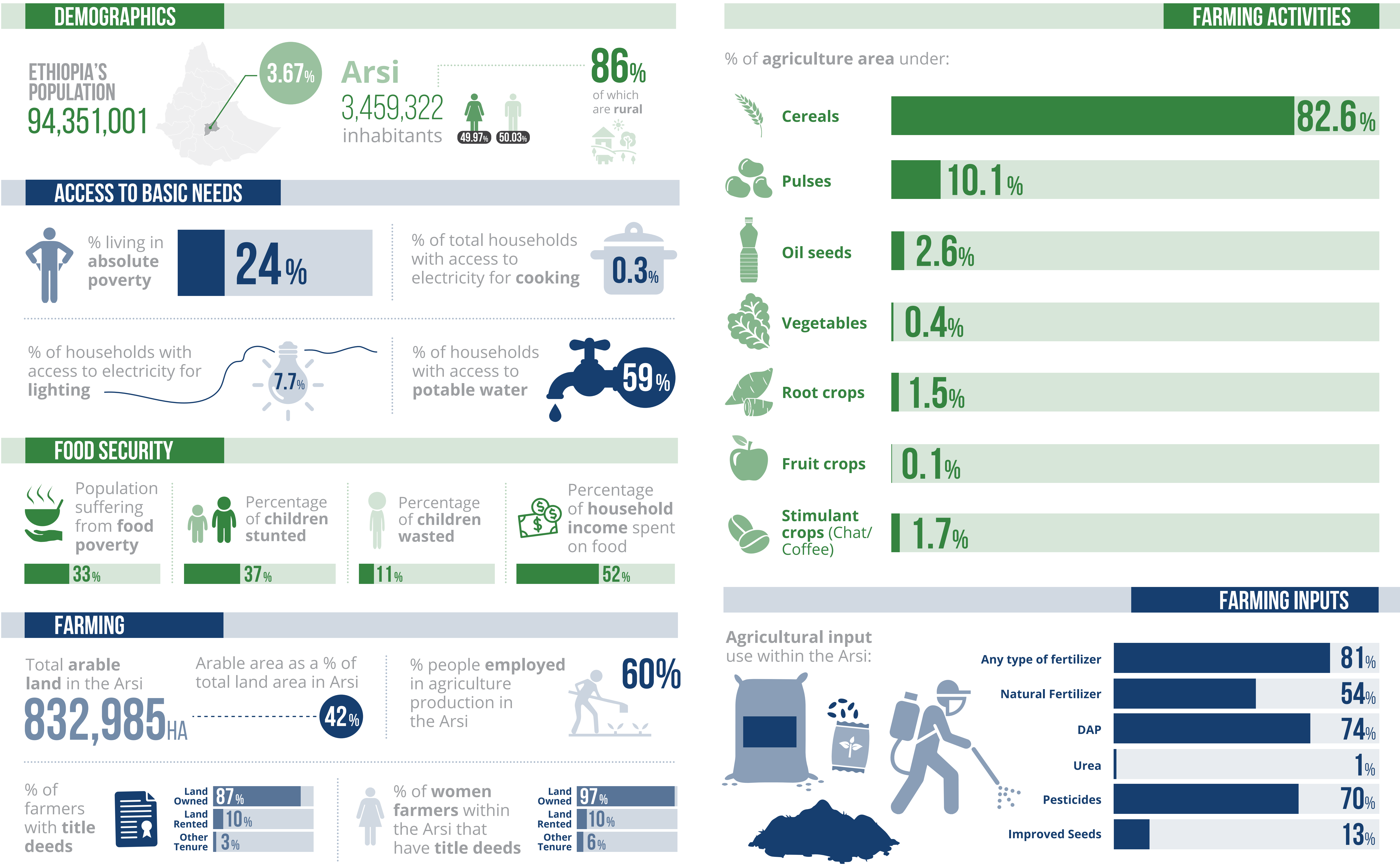
The main crops grown in Arsi include wheat, which occupies 208,308 ha; teff on 122,579 ha; barley on 91,824 ha; maize on 68,529 ha; sorghum on 30,039 ha; faba beans on 31,003 ha; peas on 16,715 ha; linseed on 14, 176 ha; root crops on 9,429 ha; beans on 9,109 ha; and vegetables on 3,746 ha. The most common vegetables include cabbages, tomatoes, and peppers. Meanwhile, the most common root or tuber crops are beetroot, carrots, onions, potatoes, and garlic. Common cash crops grown in Arsi include coffee, khat, gesho, and fruit crops. Cereal crops occupy the most the agricultural land area at approximately 83%, followed by pulses at 10%, oilseeds at 3%, vegetables at 0.4%, and root crops at 0.1% (CSA, 2016).

The major types of livestock kept in Arsi are cattle, sheep, goat, bees, and poultry. These different types of livestock provide farmers with different products: cattle provide milk, butter, cheese, and beef, while sheep and goats provide mutton and goat meat, respectively. Cattle, sheep, and goats also provide skin and hides, which are important export products for Ethiopia. Poultry provides eggs and chicken meat, and bees yield honey and wax.

Agricultural production is characterized by sub-optimal input use and mechanization. For instance, only about 13% of the farmers in Arsi use improved seeds (CSA, 2016). This situation is due to the structure of the seed system in Ethiopia, which is highly centralized and controlled by the Ministry of Agriculture and Natural Resources. The use of fertilizers is relatively high; approximately 81% of the households in Arsi utilize at least one form of fertilizer, with 54% using natural fertilizer, 74% diammonium phosphate, and only 1% using urea.

Women and men roles defer within the Arsi. In terms of division of labour in the household, women's primary activities include food storage and preparation, milk processing, post-harvest processing, fetching water and cooking fuel,

Figure 2. Livelihoods and agriculture in Ethiopia



cooking, and barn cleaning. In contrast, men are active in land preparation, mainly land opening, harvesting, and weeding (Nahusenay, 2017).

2.4. Agricultural value chain commodities

Arsi features a broad diversity of agricultural production systems with several value chains prioritized for development interventions by the government as well as various organizations and programs. **GIZ prioritized three value chains, namely wheat, faba beans, and honey, for their potential in contributing to food security and importance in the zone and country.**

2.4.1. Wheat

Wheat is an important cereal crop in Ethiopia and in Arsi. It is the second most-consumed staple food in Ethiopia after maize, contributing 15% of caloric intake. Other important staple foods in Ethiopia include teff, sorghum, and enset, each contributing between 10-12% to caloric intake. Nationally, wheat occupies 14% of farmland, making it the fourth most-produced crop after teff, maize, and sorghum (CSA, 2019). In Arsi, the case is different; wheat is the leading cereal and food crop in the area. This is because Arsi lies in the wheat-producing belt in the Ethiopian highlands. Arsi is responsible for 15% of the total wheat production in Ethiopia (GFA, 2016).

Most of the wheat produced in Arsi (51%) is for household consumption, 21% is saved as seed, and 24% is sold (CSA, 2015). Most farmers sell their produce immediately after the harvest during Meher, the main season that lasts from July to December. In some cases, farmers sell their produce a few months after harvest in order to avoid post-harvest losses caused by pests, crop damage, and aflatoxin. Most wheat in Arsi is sold to local wholesales or assemblers who aggregate the produce to sell to private traders and millers, processors, or bakeries. However, at times farmers may opt to sell directly to final consumers during weekly market days. The price of wheat has more than doubled between 2000 and 2013 due to increased demand for wheat and wheat products in the domestic market (Gebreselassie et al., 2017). Price is fluctuating since then (FAOSTAT (2020). With increased demand and low production, Ethiopia has been forced to import wheat to compensate for the deficit.

Despite the potential of wheat farming to enhance food security and agricultural livelihoods, farmers have not embraced the use of modern inputs. Less than 10% of farmers in Ethiopia use improved seed, and only 1% use irrigation, and 35% use pesticide (CSA 2014). This limits the productivity of the wheat. To avoid the shortcoming of a centralized seed system such as delays in the delivery of seed, farmers opt to save their harvest and use it as seed for the next season.

2.4.2. Faba beans

Ethiopia is the world's leading producer of faba beans. Locally, faba beans are the most important pulse both in volume and production area. They provide a cheap source of protein for most households. The two regional leaders in faba bean production are Amhara and Oromia, with Arsi the foremost producer in Oromia (CSA, 2015). Faba beans cover approximately 4% of the total farmland in Ethiopia and 30% of the total land area under pulses, with an average production of 21.17 quintal tons per ha (CSA, 2019). Arsi accounts for 10% of the total faba beans produced in Ethiopia, signifying the zone's potential in production as only 31,003 ha is under faba beans. Most of the produce in Arsi is utilized for household consumption (54%), approximately 20% is saved as seed, and 23% is sold (CSA, 2015).

As in the wheat value chain, farmers do not use improved seeds and instead save their produce to use as seed for the next season, even though 31 improved faba bean varieties have been approved for sale. These improved varieties are more productive and resistant to significant biotic and abiotic stresses than local

or recycled seed (MoANR, 2016). This situation underscores the need to reform the centralized seed system in Ethiopia. Most farmers in Arsi either sell their beans to local retailers and wholesalers or regional wholesalers. These traders then either sell the beans locally or export them. However, they undertake simple value addition before exporting the beans. First, the beans are cleaned, sorted, and graded, with some level of quality control applied. The next steps include dehusking and splitting, then packaging and labeling, before the beans are either exported or sold locally.

In addition to sub-optimal use of improved seeds, the main challenge complicating faba bean production in Arsi is the occurrence of diseases. The most common faba bean diseases include chocolate spot, rust, and *Ascochyta* blight. Farmers can alleviate this problem, however, by adopting better faba bean varieties available in the market that are high-yielding and disease-resistant (Wolde and Ashenafi, 2014).

2.4.3. Honey

Ethiopia is a leading producer of honey in Africa and globally. Worldwide, it is among the top 10 honey producers and 4th in wax production (Teferi, 2018). There are over 10 million honeybee colonies spread around the country, producing 66 million kilograms of honey in 2018 (CSA, 2018). Ethiopia's broad range of agro-climatic conditions and its biodiversity enable it to host numerous an array of honeybee colonies, resulting in honey that is diverse in both variety and quality. Of the honey produced in Ethiopia, 41% is used for household consumption and 55% is sold, while 44% of wax produced is used for household consumption and only 24% is sold. In Arsi, consumption patterns display the opposite tendencies; 70% of honey is used for household consumption and 24% is sold, whereas 40% of wax is used for household consumption and 60% is sold (CSA, 2015).

Ethiopia's honey sector can be classified into three categories based on the mode of production: traditional, transitional, and modern. In the traditional system, honey is produced using traditional beehives, mostly cylindrical in shape, that are located in the forest and backyards and account for almost 96% of the total hives in Ethiopia (Teferi, 2018). In the transitional system, farmers have abandoned the use of old hives, but have not fully adopted modern hives; they use Kenyan and Tanzanian top-bar hives, mud-block hives, and Ethio-ribrab hives. This system accounts for about 1% of total hives. Lastly, the modern system accounts for about 3% of total hives and involves the use of modern framed hives. The traditional system is still popular in Ethiopia, even if it offers the lowest productivity rate at 8 kg per hive per season, compared to the other two at 13 kg. This system is, however, dominant because honey production is not perceived as a serious agribusiness venture in most parts of Ethiopia (Teferi, 2018). After harvesting honey in its crude form, most farmers sell it to local collectors who then sell to aggregators. These aggregators either sell the honey in its crude form in the domestic market or sell to processors who, in turn, first filtering the honey, then pasteurize it and package it to either sell locally or export.

The honey value chain offers several growth opportunities based on the increasing demand for bee products like honey and wax, and on Ethiopia's diverse agro-climatic conditions and agroecology. The diverse agro-climatic conditions and agroecology of Ethiopia increase the probability of marketing different varieties with different tastes. This goal can be achieved by clear geographical indication in labels and marketing. However, opportunities to do so have yet to be fully realized due to continuing use of the traditional system that is less productive. Additionally, since apiculture has yet to be adopted as an agribusiness venture, most farmers face several challenges such as honeybee pests, predators, and diseases, poor harvesting methods, and deforestation. These challenges result in absconding and migration of honeybees, both of which reduce farmers' productivity (Teferi, 2018).

2.5. Agricultural sector challenges

The agricultural sector in Arsi faces several challenges, such as suboptimal use of inputs, over-reliance on rainfed agriculture, and poor agricultural practices such as mono-cropping. Faba bean farmers in Arsi are characterized by low use of inputs, while wheat farmers are characterized as medium users of inputs such as chemical pesticides, fertilizer, and improved seeds varieties (GFA, 2016). Since Arsi lies within the wheat-producing belt in Ethiopia and wheat is considered the main cash crop, most wheat farmers in the area use more inputs than faba bean farmers do. Sub-optimal use of inputs results in low productivity and contributes to the high poverty rate by reducing farmers' income and further decreasing their ability to purchase necessary inputs.

Poor agricultural practices such as mono-cropping of wheat and low adoption of post-harvest technologies and soil conservation practices limit farmers' ability to produce. Soil and water conservation practices are essential to controlling land degradation and soil erosion, and they enhance water infiltration and ultimately improve soil fertility and productivity. Farmers in Arsi still practice mono-cropping and rarely practice crop rotation and intercropping.

Agricultural production in Arsi can be characterized as basic and labour-intensive due to low mechanization. The causes of low mechanization include a lack of financial resources and Ethiopia's land tenure system. Insecure land tenure disincentives farmers from investing in their farms. However, over the years, the government has been issuing land certificates to farmers.

In addition to these problems, farmers still face poorly developed markets in Oromia. Poor price transmission channels from markets to farmers result in farmers receiving less income, while middlemen take the lion's share. Additionally, undefined standards of quality and quantity put farmers at a disadvantage if they deal with dubious traders. This problem is common in the honey and wheat value chains.

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3. POLICIES, STRATEGIES AND PROGRAMS ON CLIMATE CHANGE

KEY MESSAGES

- The Ethiopian government has instituted several policies and strategies to address climate change.
- These policies and strategies have been advanced through collaborative efforts with other developmental institutions.
- These policies and strategies which are currently largely funded by development partners can only be fully implemented through enhanced institutional capacity and continued governmental financial support.

In Ethiopia, different policies are established at five different levels of government: namely, the federal government, regional government, zonal administrations, woreda, and kebele[3]. The federal government is, however, responsible for formulating national policies, strategies, and implementation plans, and for budget allocation. Based on this mandate, the national government has been able to create several policies, strategies, and programs aimed at enhancing adaptation to climate change along the three prioritized value chains.

The national government recently published the Value Chain Roadmap for Pulses that strives to boost local productivity and production quality, improve intermediation by strengthening the connection between producers and relevant intermediaries, and maximize the sector's developmental dividend (ICT and the Government of Ethiopia, 2019). This roadmap provides a suitable platform to augment the production of faba beans and farmers' access to high-value markets, especially export markets. This plan could increase farmers' income and improve their livelihoods, hence strengthening their adaptation capabilities to the adverse effect of climate change.

In 2010, the federal government founded the ATA, which was mandated to improve farmers' productivity by introducing new technologies and approaches that can accelerate agricultural development. The ATA also uses market-driven and geographically based approaches to accelerate farmers' transition from subsistence to commercial orientations and heighten commercialization. Through this agency, the federal government aims to support mechanization in order to improve productivity along the three prioritized value chains. Another goal is to enhance agribusiness culture by improving market infrastructure and rural financial services.

The second phase of the Growth and Transformation Plan (2016-2020) strives to strengthen agricultural marketing and cooperatives, expand farm extension, and provide agricultural inputs. It will do this by gradually shifting farmers from traditional to high-value crops and livestock in the highlands, where Arsi is located. The plan plays a critical role in increasing the productivity and marketability of faba beans and honey in both local and international markets. It would also contribute to self-reliance in wheat production.

The Agricultural Policy Investment Framework (PIF) from 2011-2020 aims at sustainably increasing rural incomes and national food security by enabling farmers to produce more, sell more, nurture the environment, and eliminate hunger, while protecting vulnerable farmers against shocks. The PIF lessens land degradation and improves the productivity of natural resources. It helps protect the environment and enhance honey production in Ethiopia.

Ethiopia's Climate-Resilient Green Economy Strategy, formulated in 2011, acknowledges the detrimental effects of climate change and the need to address it through a comprehensive approach that considers all aspects of the economy. The strategy aims at transforming Ethiopia into a middle-income country with a climate-resilient green economy by 2025. It seeks to achieve this by reducing emissions levels and enhancing farmers' resilience to climate change by improving crop and livestock production practices, protecting and re-establishing forests, expanding electricity generation, and establishing modern and energy-efficient technologies in transport, the industrial sector, and buildings. The first and second strategies are critical to addressing the key issues affecting farmers in Arsi along the wheat, faba bean, and honey value chains.

Successful implementation of these policies and strategies is critical to addressing the risks and vulnerabilities affecting farmers in Arsi and all of Ethiopia. Most of the aforementioned policies and strategies, however, have encountered several challenges to implementation. Implementation can only be achieved through augmented institutional capacity and continued government support in terms of financial support. Additionally, there is a need to develop gender-inclusive policies and strategies, intensify collaborative work with developmental partners, invest in improving infrastructure, and broaden access to essential goods and services.

3 Woreda are the third-level administrative divisions of Ethiopia. They are also called districts. While Kebele are the smallest unit and at times called the wards.

4. GOVERNANCE, INSTITUTIONAL RESOURCES AND CAPACITY

KEY MESSAGES

- » Several government institutions support the agricultural sector, including the Ministry of Environment, Forest and Climate Change (MEFCC), the Ministry of Agriculture and Natural Resources (MoANR), and the Agricultural Transformation Agency (ATA).
- » In addition, the Ethiopian Institute of Agricultural Research and the universities together comprise the National Agricultural Research System (NARS), which collaborates with private and non-governmental organizations to elevate agricultural livelihoods and productivity.
- » Numerous international partners are active in Ethiopia; the International Center for Agriculture Research in the Dry Areas (ICARDA) and the International Centre of Insect Physiology and Ecology (ICIPE) are key players in the faba bean and honey value chains, respectively.
- » There are also several non-governmental organizations (NGOs) whose work helps advance the agricultural sector in Arsi, including the German Agency for International Cooperation (GIZ), Farm Africa, the Red Cross, and the Netherlands Development Organization (SNV).

Several public, private organizations are directly and indirectly involved in the agricultural sector within Arsi and Ethiopia. Several federal institutions are mandated to deal with climate change adaptation and mitigation with the country such as the Ministry of Environment, Forest and Climate Change (MEFCC), the Ministry of Agriculture and Natural Resources (MoANR), the ATA, the Ethiopian Institute of Agricultural Research, and the universities. The latter two together constitute the National Agricultural Research System (NARS), made up of institutions at the forefront of research to generate and promote the latest technologies and practices. The MEFCC, meanwhile, is responsible for the coordination of national climate change-related activities in Ethiopia. The MoANR, finally, is responsible for promoting climate-smart agricultural practices in Ethiopia under the different projects and programs it implements.

The NARS works in collaboration with other private organizations and non-governmental organizations (NGOs) to improve farmers' livelihoods and productivity. Research institutions that collaborate with the NARS include the Consultative Group on International Agricultural Research (CGIAR) Centers, the International Maize and Wheat Improvement Center, the World Agroforestry Centre, the International Crops Research Institute for the Semi-Arid Tropics, the International Livestock Research Institute, CIAT, the International Water Management Institute, the International Center for Agriculture Research in the Dry Areas (ICARDA), and the International Centre of Insect Physiology and Ecology (ICIPE). Most of the CGIAR Centers work on different value chain rather than on wheat, honey, or faba beans. For instance, ICIPE is actively involved in the honey value chain through the More Young Entrepreneurs in Silk and Honey project, which seeks to enable young people to access finance, markets, and information services; to build and strengthen their technical, entrepreneurial, soft, and financial literacy skills; and to involve youths in value-addition activities for honey products. ICARDA through a project funded by the United States Agency for International Development in partnership with the NARS are involved in the dissemination of malt barley and faba bean varieties and of technologies that support sustainable food, nutritional security, and market opportunities in the highlands of Ethiopia. ICARDA is scaling up the adoption of good and integrated crop management techniques and of new faba beans varieties such as Walki, a high-yielding, disease-resistant, and waterlogging-tolerant variety.

Some NGOs working in Arsi include GIZ-Green Innovation Center, Farm Africa, the Red Cross, and the Netherlands Development Organization (SNV). For instance, along the honey value chain, SNV and Farm Africa provide extension services, market linkages, and modern beehives for farmers. The Red Cross has been supplying humanitarian aid to communities in Arsi during droughts and flash floods. Additionally, the Food and Agriculture Organization of the United Nations is actively involved with farmers in Arsi, promoting accessibility to quality wheat seeds.

5. CLIMATE CHANGE-RELATED RISKS AND VULNERABILITIES

KEY MESSAGES

- Drought, heat stress, shorter growing seasons, and flash floods are the main climatic hazards to agricultural production in Arsi.
- Arsi is highly suitable for wheat production and moderately suitable for faba bean production.
- Farmers' perceptions underscore climate modeling results; they cite drought, changing intensity of rainfall, high temperatures, and shorter growing seasons as pressing climatic hazards.
- Wheat and faba beans are highly affected by drought and shorter growing seasons, while honey production is impacted by droughts and high temperatures. All these climatic hazards have a considerable effect on the on-farm production stage.
- The above climatic hazards result in a reduction in productivity that endangers farmers' welfare and the business prospects of traders, assemblers, wholesalers, and processors; all of this results in an increase in final market prices.

5.1. Farmers' perceptions on climate change

Different agricultural stakeholders have diverse views and opinions on climate change and its impact on agricultural productivity. A better understanding of their perceptions can facilitate the design of inclusive policies that strengthen farmers' resilience to climate change. Farmers' perceptions and knowledge influence their willingness to adopt new agricultural technologies.

Most farmers in Ethiopia acknowledge climate change and are aware of indicators such as a changes in temperature, inconsistent rainfall, declining yields, increasing incidence of crop diseases, crop failure, and soil erosion (Tesfahunegn et al., 2016; Asrat and Simane, 2018; Cherinet and Mekonnen, 2019). Farmers have noticed that temperatures have increased over time and have drawn attention to temperature-related indicators. For instance, they have highlighted an increase in the occurrence of heat-induced animal and human diseases, longer months with high daytime temperatures, and rapid disappearance of water sources due to evaporation (Asrat and Simane, 2018). Farmers have also observed irregular rainfall patterns and pointed out that rainfall intensity has reduced over time (Tesfahunegn et al., 2016; Cherinet and Mekonnen, 2019).

Additionally, farmers indicate that the rainy season has become shorter over time, as indicated by early onset and early cessation of rainfall (Kahsay et al., 2019). This change forced many farmers to adopt drought-tolerant crop varieties, adjust planting times, and diversify their food crops. **All farmers agreed that crop yields have reduced over time and acknowledge the need to adopt new agricultural practices.** All the changes they describe result in increased food insecurity, a decline in water availability, and deterioration of farmers' livelihoods.

5.2. Climate change and variability: historical and future trends

Arsi is generally a cool region with temperature varying between 10 and 25°C, experiencing high temperatures from March to June and low temperatures from October to January. The area has two rainy seasons. The first season, Belg, starts in mid-February and ends in June, with the most rainfall in April. The second, Meher season lasts from July to December, with the most rainfall in August. The Meher season receives more rainfall than Belg in terms of precipitation per month.

The length of the growing season, as measured by the number of days rainfall was received, has been decreasing over time in both Belg and Meher (Figure 3). This trend continues into the future; it is predicted that the length of the season will reduce by an additional 20-30 days. This shorter growing season presents a major hazard to which farmers must adapt by changing their planting days and seed varieties and by embracing irrigation.

Drought, as measured by the number of consecutive dry days and moisture stress, has been a major hazard in Arsi (Figures 4 and 6). Droughts occurred frequently from 1981-2015, with the driest year in recent history experienced in 2008. Arsi is predicted to become drier in the future, with the number of consecutive dry days increasing both in Belg and Meher. However, droughts tend to be more common and longer in terms of days in Belg than in Meher. Heat stress, meanwhile, as measured by the number of days with a maximum temperature greater than or equal to 35°C, has been non-existent in Arsi. This situation is expected to change, however, as the temperature rises, leading to the possibility of heat stress in the future in both Belg and Meher.

Floods have not been a major hazard in Arsi; however, in the future, average precipitation is expected to increase, leading to the possibility of flash floods mostly in Meher (Figure 5). To reduce the risk of flash floods and avert their adverse effects, it is important to increase the adoption of soil and water conservation techniques.

Figure 3. Historical (left), future projected (center), and projected change (right) for the length of the growing season (average of last 30 years) in Belg for Arsi.

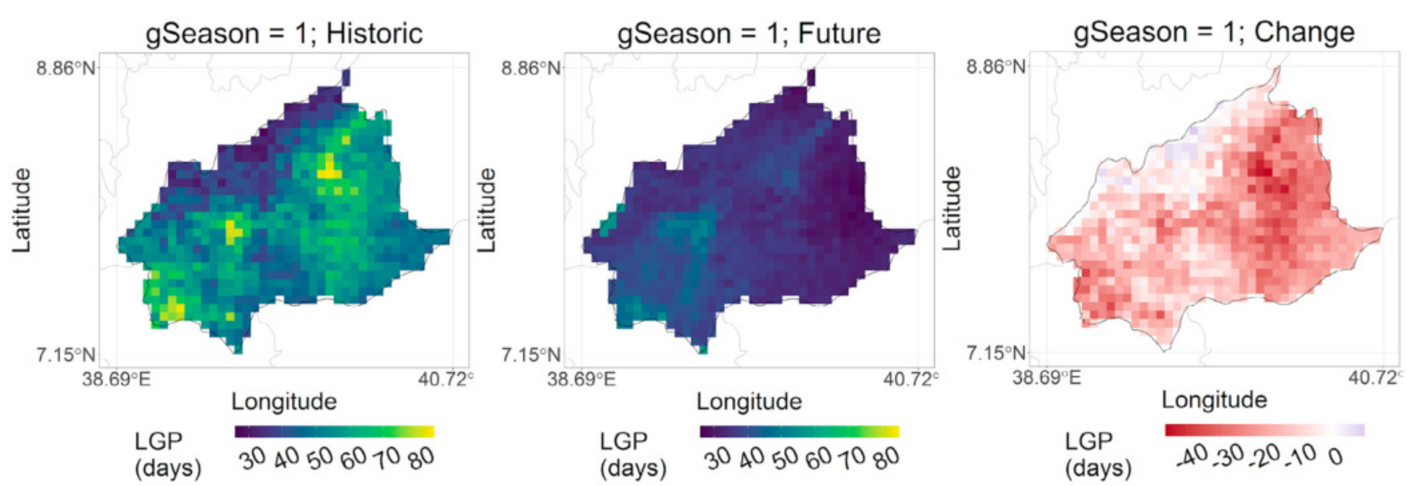


Figure 4. Historical (left), future projected (center) and projected change (right) for the maximum number of consecutive dry days (average of last 30 years) in Belg for Arsi

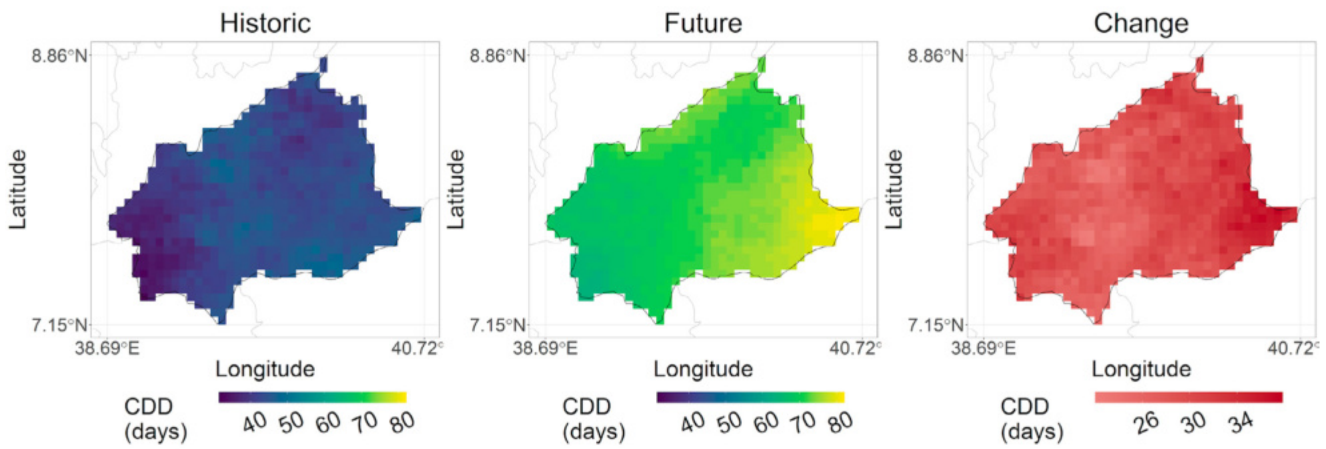


Figure 5. Historical (left), future projected (center), and projected change (right) for 95th percentile of daily precipitation in millimeter (average of last 30 years) in Meher for Arsi

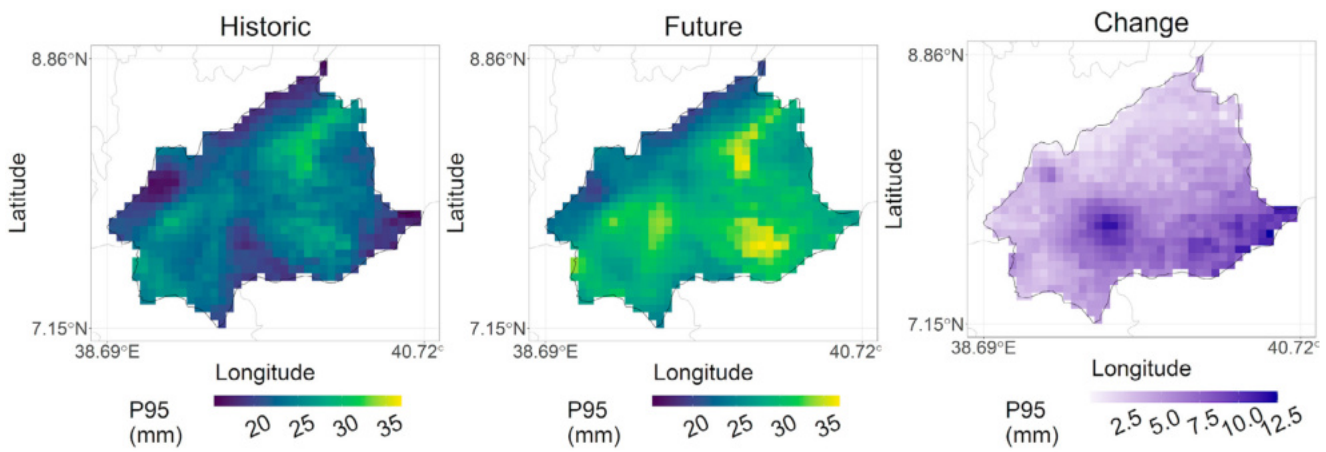
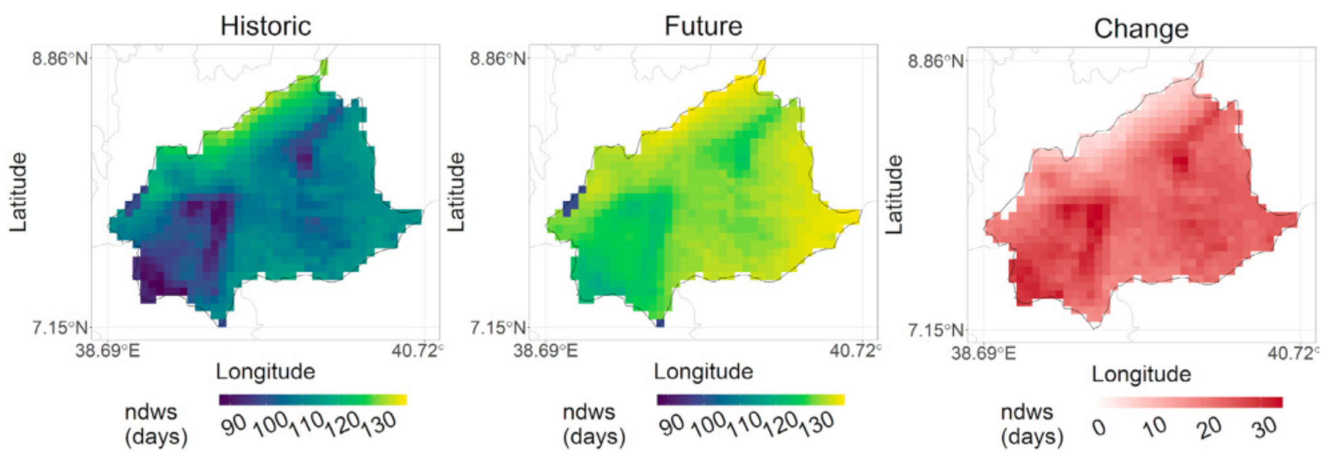


Figure 6. Historical (left), future projected (center) and projected change (right) for the number of moisture stress days (average of last 30 years) in Belg for Arsi



5.3. Crop suitability analysis

We ran a crop suitability analysis based on the EcoCrop model (Ramirez-Villege et al., 2011), which considers precipitation and temperature in Arsi. The results indicate that nearly 50% of Arsi is highly suitable (80 to 100%) for wheat production, with a majority of the rest of the zone moderately suitable (40-80%). Future climate projections show that the northern and eastern parts of Arsi will become poorly suitable (0-40%) for wheat production (Figures 7 and 8). **These projections indicate the need to enhance farmers' climate adaptative capacity to deal with the expected decline in suitability.** However, the southwestern region will change from moderately to highly suitable.

On the other hand, 75% of Arsi is moderately suitable for faba bean production, with a few parts in the north highly suitable; however, this highly suitable area represents less than 10% of the zone. **Future climate projections show nearly 30% of Arsi, specifically its northern and central areas, will become highly suitable (Figure 9 and 10).** Additionally, the eastern and southwestern parts of Arsi that once showed poor suitability (0-40%) will become moderately suitable for faba bean production.

Figure 7. Historical and future (scenario RCP 8.5, periods 2030 and 2050) suitability for wheat in Arsi

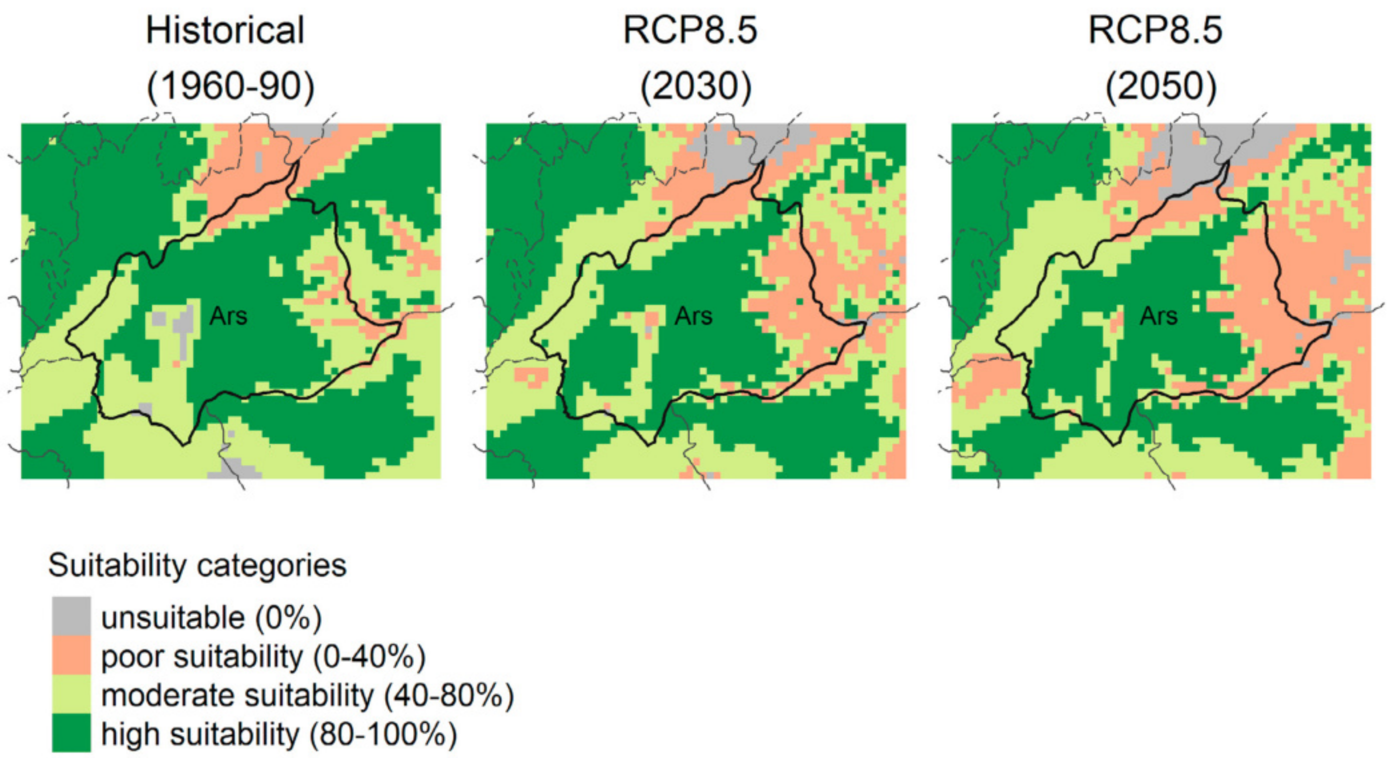


Figure 8. Suitability change of wheat production in Arsi

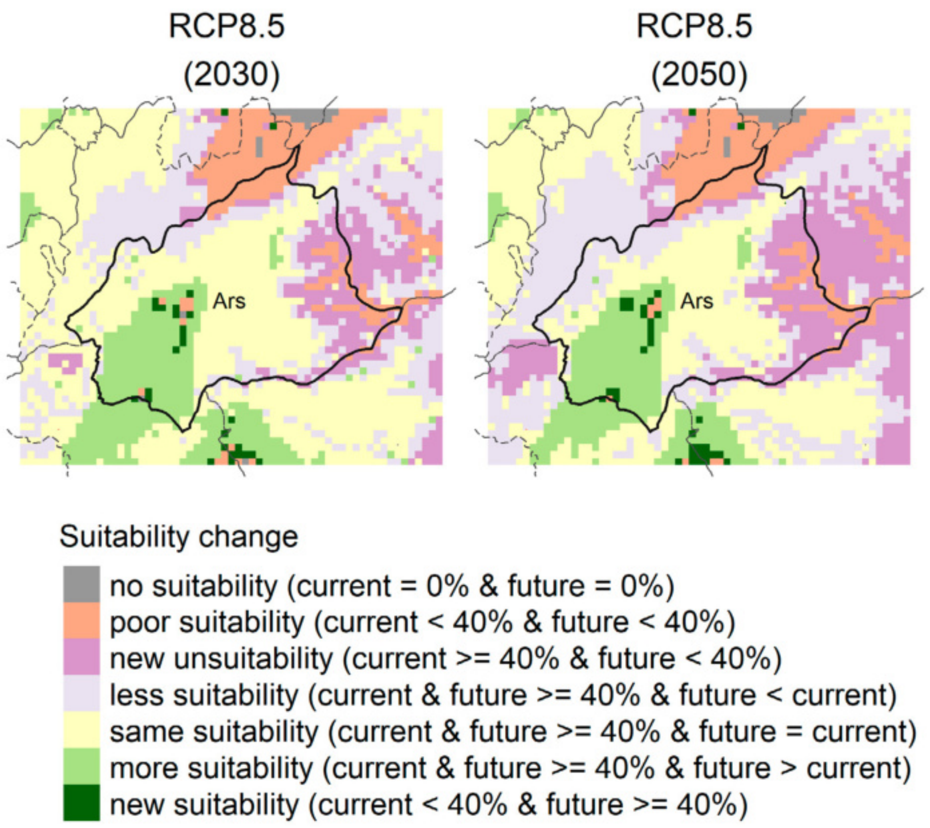


Figure 9. Historical and future (scenario RCP 8.5, periods 2030 and 2050) suitability for faba beans in Arsi

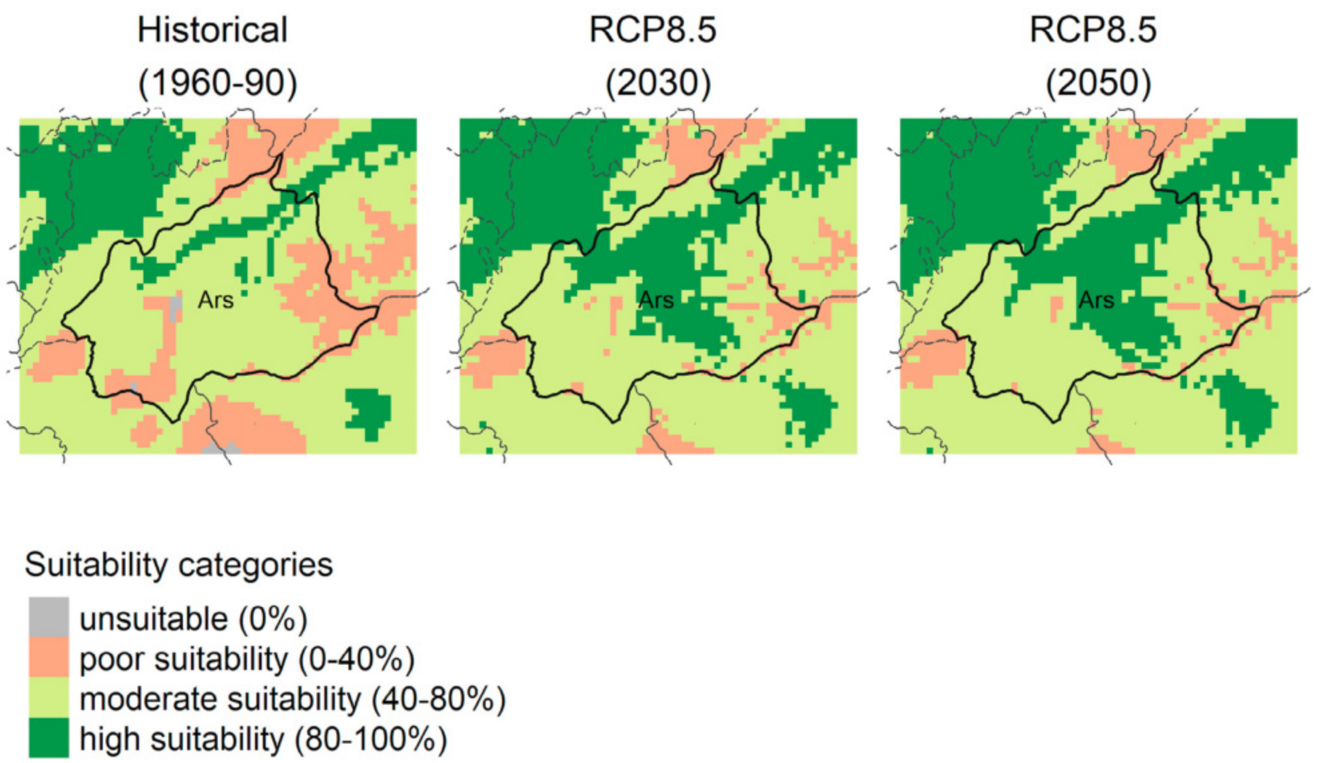
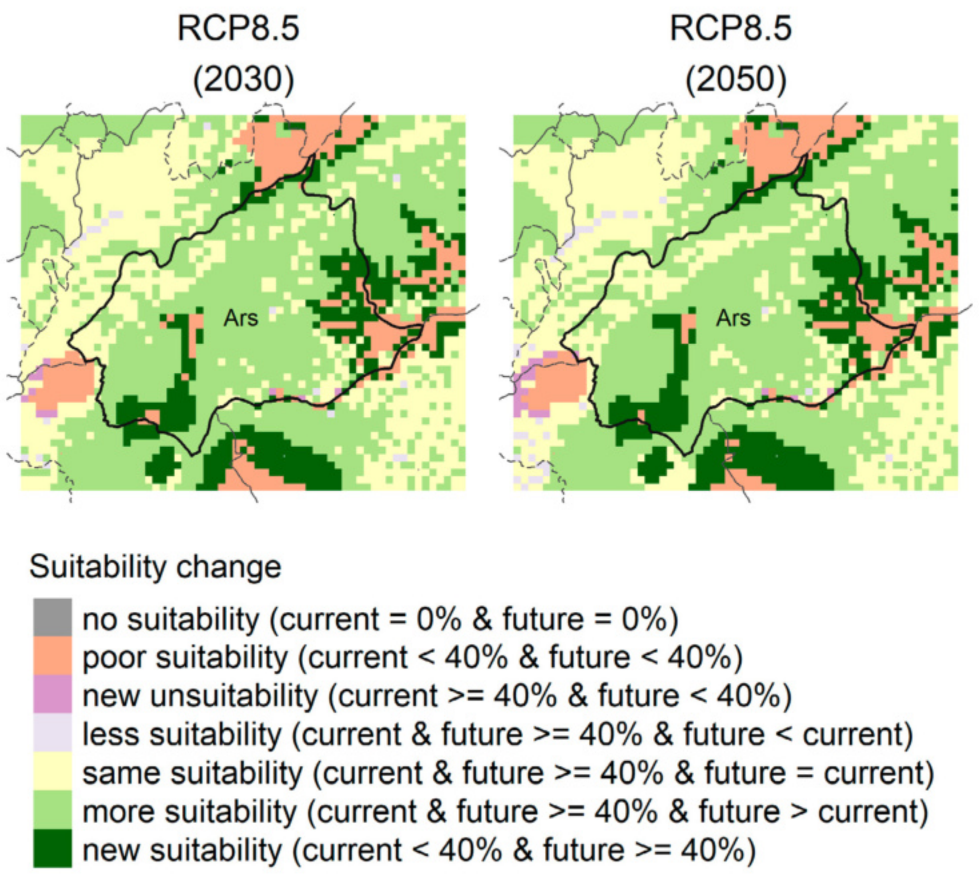


Figure 10. Suitability change of faba beans production in Arsi



5.4. Climate vulnerabilities across agriculture value chain commodities

We conducted a survey to identify the two most frequent hazards affecting the prioritized value chains. The survey targeted key informants who are highly knowledgeable about each value chain. The response rate across the three value chains was 11, 7 and 4 key informants along the wheat, honey, and faba bean value chains, respectively.

5.4.1. Wheat

The two main climatic hazards affecting wheat are a shorter rainy season and droughts. Other noticeable hazards include late and early onset of rainfall, floods, and extreme rainfall.

Ethiopia has been faced with a few drought events in the last 50 years, and droughts are also expected to influence production in the future. Droughts are associated with increased temperatures and a reduction in the amount of soil water. In drought conditions, it is more probable that wheat production will face challenges like heat and moisture stress. Droughts also inhibit wheat growth and can result in an increased incidence of insects and pests, as well as in weed infestation. Additionally, they make it difficult to cultivate the fields due to the formation of hard soil pans. This effect is especially significant since most wheat-growing soils in Arsi are clay soils called black vertisols. A combination of inhibited growth rate, disease, and weed infestation reduces the productivity of wheat. In turn, the effects of drought reduce the quality and quantity of marketable wheat, constricting the trading capabilities of other value chain actors. Additionally, droughts can contribute to an increase in price markets, which tends to drive up the price of basic wheat products in the economy. In terms of severity, droughts have a major impact on the on-farm, input, and marketing stages, but just a moderate impact on the post-harvest stage.

Shorter rainy seasons restrict the growing season. Additionally, the amount of rainfall received during the season may be reduced. **A shorter growing season is a serious hazard since the production of wheat is a step-by-step process; if a farmer is late in sowing, they face an increased probability of crop failure.** On the other hand, if they plant at the right time and lack water for irrigation, the crop will wither. In most cases, a reduction in the growing season results in a smaller leaf area index and shorter plant height during early growth stages, leading to a lower wheat yield (Tataw et al., 2016). Studies in Ethiopia have established a high correlation between the wheat yield and the number of rainy days, which determines the length of the growing season (Bewket, 2009; Bekele et al., 2017). Similarly to drought, a shorter rainy season may cause problems for traders and processors, and can contribute to higher prices for wheat products purchased by consumers. This hazard has a major impact during the on-farm stage and low impact on the input, post-harvest, and marketing stages.

5.4.2. Faba beans

The two main climatic hazards affecting the faba beans value chain include a decrease in the length of the growing season and droughts. A shorter growing season can result in poor germination and crop failure. This hazard most acutely impacts farmers who are unable to implement irrigation and adjust their planting dates. Changing planting date is only possible if farmers are provided with accurate weather forecast information in advance. Poor germination, a low germination rate, and crop failure reduce farmers' yield, and hence the amount of tradeable faba beans. As a result, faba beans traders, wholesalers, and exporters all incur additional costs while searching for new sources of faba beans. In terms of severity, a shorter growing season has a major effect on the on-farm stage and moderate effect on the input, post-harvest, and marketing stages.

Droughts hinder the growth of faba beans by diminishing the germination rate, flowering, and productivity of the plants. In addition to the germination rate, droughts tend to lessen all growth parameters: plant height and weight, shoot fresh, shoot dry, leaf area, and the amount of chlorophyll. Higher temperatures associated with droughts increase the rate of evaporation, potentially resulting in water stress. Water stress, in turn, makes land preparation difficult due to the formation of hardpans. Since most of the area's farming activities are not mechanized, hardpans increase the cost of production and reduce farmers' profit margins. Additionally, droughts contribute to more frequent outbreaks of chocolate spot disease, aphids, and faba bean rust disease. Chocolate spot disease reduces yield by 34-60%. Lower production decreases marketable volume, negatively impacting traders, wholesalers, and exporters because they have to seek more produce in other regions. With less income, farmers are unable to procure necessary inputs to use in the next season.

5.4.3. Honey

The two most pressing climatic hazards that affect the honey value chain are droughts and high temperatures. Other hazards, but with low magnitude, include floods, hailstorms, late and early onset of rainfall, and delay in the cessation of rainfall. Droughts tend to decrease the amount of honey-producing flora and the size of foraging areas, which in turn reduces food availability for bee colonies, including nectar and pollen. As a result, bees experience a low population growth rate and produce less honey. Droughts are also associated with absconding and migration of bee colonies dues to increased temperatures. Because water is less available and temperatures are higher, the quantity and quality of nectar are reduced, and so bees tend to produce honey and wax of lower quality and quantity. During droughts, there is an increased incidence of disease outbreaks, especially chalkbrood disease, which destroys the colony.

Like droughts, increased temperatures may result in absconding and may decrease the amount of honey-producing flora and the size of foraging areas. These two climatic hazards affect other farming activities; for instance, they often lead to increased use of chemical pesticides and herbicides that can kill honeybees. Due to smaller colony sizes and lower production capabilities, farmers' income declines. A reduction in marketable produce can drive up market prices for final consumers and might mean less business for traders and wholesalers of locally produced honey. Additionally, plants processing honey and wax run into losses as they face increased production costs to procure honey and run below capacity.

However, the severity of the impact of these hazards varies at different production stages. Drought has a moderate impact on the input and post-harvest stages but a major impact during the on-farm and marketing stages. On the other hand, high temperatures have a low impact on the input and marketing stages, but a moderate and a major impact on the post-harvest and on-farm stages, respectively. This information suggests the production sector is profoundly vulnerable to the two hazards.

6. ADAPTATION TO CLIMATE CHANGE AND VARIABILITY

KEY MESSAGES

- This report identifies ranked adaptation strategies to best cushion farmers against the adverse effect of climate change.
- For wheat farmers, the most promising strategies include the use of mobile seed cleaners, Alemayehu row seeding technology (ART), hermetic bags for storage, crop rotation, compost manure, and improved ploughing.
- For faba bean farmers, adaptation strategies include crop rotation and use of an improved plough called a Berken Maresha.
- Bee farmers might implement agroforestry, integrated crop protection, reduced pesticide use, provision of extension services, and the construction of a honey accelerator platform.
- The cost-benefit analysis (CBA) results indicate use of improved faba bean seed varieties is profitable with moderate (12%) risk of failure.

Given the climatic hazards mentioned above, most farmers have adopted several coping strategies along the honey, faba bean, and wheat value chains. Additionally, farmers have adopted other practices that cut across the two value chains.

6.1. On-farm adaptation strategies

The GIZ, through the Green Innovation Centres, has been implementing several practices to enhance farmers' resilience and coping strategies. Along the wheat and faba bean value chains, they are training farmers in the use of hermetic bags for storage, crop rotation, the use of compost manure, and improved ploughing using a Berken Maresha. Additionally, wheat farmers are provided with mobile seed cleaners and encouraged to adopt Alemayehu row seed technology (ART). All these practices are facilitated through the client-centered extension approach and farm service centers. Farmers are encouraged to adopt integrated crop protection and management and reduce their use of pesticides to help protect bees. Additionally, they are working with the Agricultural Transformation Agency (ATA) to support the establishment of a honey business incubator and accelerator platform in an effort to export honey from Arsi.

Farmers have employed several of their own coping strategies to maximize their production and limit the adverse effects of climate change. Wheat and faba bean farmers within Arsi are engaged in a variety of coping strategies: changing planting dates, intercropping, planting trees, and adopting elements of soil and water conservation, crop and livestock integration, and better weeding management techniques. Bee farmers are using traditional control methods against honey and bee pests and predators, such as using metal or plastic to cover their hives.

However, there still exist several practices that have not been fully adopted by farmers. Along the wheat and faba bean value chains, there is a need to create farmer groups that can help in the purchase of inputs and dissemination of information. Through such groups, farmers can also be taught about rainwater storage techniques, about erosion control measures such as relay cutoff and stone bunds, and about soil analysis. Together with national research centers, the government has an opportunity to help breed new, superior varieties that are resistant to most local diseases and to heat stress, including varieties of faba beans that have high biomass so their straw can be incorporated as fodder. It is crucial, however, to supplement these efforts by improving seed distribution channels to ensure timely delivery and by enhancing extension services to educate farmers on the importance of adopting the latest seed varieties in the market. The government also needs to develop rules that standardize wheat trading in terms of quantities and grades. Lastly, the government can strengthen contractual agreements between farmers and value chain actors to protect both parties from production and price risks.

Along the honey value chain, there is a need to enhance extension services to train farmers in proper harvesting methods. These methods can help prevent absconding or the destruction of the colony, along with and the harmful effects of pests, predators, and diseases. Farmers also require training about the use of agrochemicals, about poisonous plants that affect honeybees, and about their control measures. Encouraging farmers to plant more trees may lessen the adverse effects of deforestation. The government can raise the value of honey from Arsi by taking advantage of geographical indication of honey produced in Arsi zone. In so doing all honey produced from the region will need to be branded it's from Arsi.

6.2. Overall ranking of the adaptation strategies

In a survey about the honey, faba bean, and wheat value chains, key informants identified several promising adaptation strategies along the four production stages (Table 1). Each stakeholder also ranked the two most promising adaptation strategies for each hazard identified earlier. This ranking was based on a scale of 1-8, where 1 indicates great promise, and 8 is less favorable. The results of the ranking process can be found in Annex. Along the faba bean value chain, crop rotation and the use of improved plough called a Berken Maresha were identified as the most promising adaptation strategies. Crop rotation is essential to enhance soil fertility and, when combined with intercropping, effectively reduces rust disease severity and progress rate (Terefe et al., 2015). Berken Maresha ploughing, meanwhile, helps increase the water infiltration rate and decrease water runoff, which is a form of soil erosion. These effects help break the hardpan and allows roots to penetrate the soil more easily, improving faba bean production (Biazin et al., 2011).

In the wheat value chain, the best adaptation strategies to deal with drought include training farmers in the use of hermetic bags for storage, crop rotation, the use of compost manure, and improved ploughing. The best strategies to tackle shorter rainy seasons are rainwater storage and the use of improved seeds. Rainwater storage helps strengthen farmers' irrigation capacity, while the use of improved seeds, such as early and drought-resistant varieties, can boost production and ameliorate the risk of crop failure. Through a client-centered approach, extension service provision is another critical adaptation strategy that helps farmers access quality information and share indigenous information and coping strategies.

Lastly, in the honey value chain, the most promising strategies to deal with drought and high temperatures include agroforestry, integrated crop protection, decreased pesticide use, provision of extension services, and the establishment of a honey accelerator platform. The first three strategies are important because they preserve bees' natural habitat so their colonies can grow, while the latter strategies enable value addition and increase farmers' income.

The strategies were highly ranked because they are sustainable, have a high impact on production, are affordable, and are readily available in Arsi. Other survey respondents attest that these practices can be adopted without difficulty due to their technical simplicity and ease of implementation at the farm level. Sustainability was another crucial consideration, since high-ranked practices help cushion farmers against current and anticipated climatic hazards.

Table 1. Specific practices within each practice group relevant to the focus value chains

STRATEGIES	WHEAT VALUE CHAIN	FABA BEAN VALUE CHAIN	HONEY VALUE CHAIN
Crop rotation	• Crop rotation*	• Crop rotation*	
Harvesting technique			• Proper harvesting methods
Improved processing			• Value addition
Integrated Pest Management			• Integrated crop protection and management* • Decreased pesticide use*
Land management	• Erosion control measures such as relay cutoff and stone bunds	• Erosion control measures such as relay cutoff and stone bunds	• Agroforestry* • Planting more trees
Manure management	• Use of compost manure	• Use of compost manure*	
Production best practices	• Improved ploughing using a Berken Maresha* • Mobile seed cleaners • Alemayehu row seed technology (ART) • Better inputs • Soil analysis • Farmer groups	• Improved ploughing using a Berken Maresha* • Better inputs • Soil analysis • Farmer groups	• Distribution of modern hives
Storage and post-harvest	• Hermetic bags for storage	• Hermetic bags for storage*	
Variety improvement	• Improved varieties • Improved seed distribution channels	• Improved varieties* • Improved seed distribution channels	
Water management	• Rainwater storage techniques • Irrigation	• Rainwater storage techniques*	
Climate services	• Enhanced extension services • Information dissemination	• Enhanced extension services • Information dissemination	• Enhanced extension services* • Training about the use of agrochemicals, poisonous plants that affect honeybees, and their control measures
Marketing	• Stronger contractual agreements between farmers and value chain actors	• Standardized wheat trading in terms of quantities and grades • Stronger contractual agreements between farmers and value chain actors • Market linkages	• Honey business incubator and accelerator platform* • Increased market value through branding

*Denotes that this is the highest-ranked adaptation strategy for its respective value chain.

Table 2. Adaptation to climate change: Strategies across major value chain commodities

WHEAT	INPUT	ON-FARM	POST-HARVEST	MARKETING
Drought	• Increased demand for quality seeds	• Increased cost of production due to increased labour demand and pest and weed infestations	• Low quality and quantity of wheat product • Most produce used for household consumption	• Reduced volume, resulting in an increase in the market price for final consumers • Increased transaction costs for traders searching for new sources of wheat
Magnitude of impact	MAJOR	MAJOR	MODERATE	MAJOR
Promising adaptation strategies	• Breeding new superior varieties resistant to both diseases and drought, use of mobile seed cleaners, use of Alemayehu row seed technology, irrigation, and crop rotation			
Shorter rainy season	• Increased demand for quality seeds • High input costs • Additional capital required for irrigation installation	• Increased losses due to crop failure • Production of a lower quality and quantity of wheat product	• Poor quality and decline in wheat yield	• Reduced volume, resulting in an increase in the market price for final consumer • Increased transaction costs for traders searching for new sources of wheat • Underutilization of processors' plants and machinery
Magnitude of impact	LOW	MAJOR	LOW	LOW
Promising adaptation strategies	• Use of improved wheat seeds, use of Alemayehu row seed technology, rainwater storage, crop diversification, market linkages, and better provision of extension services			

Strategies to mitigate both hazards

Farmers coping strategies	• Changing planting dates, intercropping, planting trees, adopting soil and water conservation, crop and livestock integration
Ongoing adaptation strategies	• Hermetic bags for storage, crop rotation, use of compost manure, improved ploughing with a Berken Maresha, and Alemayehu row seed technology

FABA BEANS	INPUT	ON-FARM	POST-HARVEST	MARKETING
Drought	• Increased demand for quality seeds • Increased demand for pesticides	• Low germination rate and flowering rate • Higher production costs due to increased labour demand and disease outbreaks	• Low quality of beans	• Low supply and high demand, leading to elevated market prices
Magnitude of impact	MAJOR	MAJOR	MAJOR	MAJOR
Promising adaptation strategies	• Adoption of high-yielding, disease-resistant, and drought-tolerant varieties, crop rotation, use of hermetic bags, market linkages, use of compost manure, erosion control measures, and improved ploughing with a Berken Maresha			
Decreased length of the rainy season	• Increased demand for irrigation facilities	• Crop failure • Higher production costs as the probability of farmers replanting and re-weeding increases	• Low quality of beans	• Low supply and high demand, leading to elevated market prices
Magnitude of impact	MODERATE	MAJOR	MODERATE	MODERATE
Promising adaptation strategies	• Crop rotation, market linkages, use of compost manure, and adoption of high-yielding, disease-resistant, and drought-tolerant bean varieties.			

Strategies to mitigate both hazards

Farmers coping strategies	• Changing planting dates, intercropping with other crops, planting trees, adopting soil and water conservation, crop and livestock integration
Ongoing adaptation strategies	• Training in the use of hermetic bags for storage, crop rotation, the use of compost manure, and improved ploughing with a Berken Maresha

HONEY	INPUT	ON-FARM	POST-HARVEST	MARKETING
Drought	• N/A	• Absconding and migration of bees • Diseases outbreaks, especially of chalkbrood disease • Decrease in honey-producing flora and forage • Reduced availability of water for bees	• Low quality of honey produced	• High market prices • Losses for honey and wax processors due to low production and high costs
Magnitude of impact	MODERATE	MAJOR	MODERATE	MAJOR
Promising adaptation strategies	• Integrated crop protection, reduced pesticides use, distribution of modern hives, provision of extension services, agroforestry, and value addition			
High temperatures	• N/A	• Absconding and migration of bees • Reduced colony size	• Low quality of honey produced	• High market prices • Losses for honey and wax processors due to low production and high costs
Magnitude of impact	LOW	MAJOR	MODERATE	LOW
Promising adaptation strategies	• Construction of a honey accelerator platform, distribution of modern hives, provision of extension services, agroforestry, and value addition			
Strategies to Mitigate both Hazards				
Farmers coping strategies	• Traditional control methods against honey and bee pests and predators, such as using metal or plastic to cover their hives			
Ongoing adaptation strategies	• Integrated crop protection, training in need to reduce the use of pesticides, market linkages, distribution of modern beehives, financial inclusion			

6.3. Cost benefit analysis of the prioritized adaptation strategies

A cost-benefit analysis (CBA) is critical when making investment decisions, including those associated with Climate-Smart Agriculture (CSA) practices. A CBA allows for the comparison of costs and returns associated with a given CSA practice compared to those already existing (Ng' ang' a et al., 2017). The existing practices are referred to as Business as Usual (BAU). Most farmers in the developing world already have conventional practices that help them cope with climate change variabilities. Some of them have been effective while others have had no impact on climate change, which is why the comparison is important. In CBA, three CBA indicators, the Net Present Value (NPV), Internal Rate of Return (IRR), and payback period are normally used to show the profitability associated with an improved practice or innovation. The NPV measures the incremental flow of net benefits from the innovation over its lifecycle, while the IRR is the discount rate that equates NPV to 0. A higher IRR indicates a high profitability potential. Payback period is the number of years it takes to recoup the initial investment.

In this profile, CBA was computed for the highest-ranked innovation under faba bean specifically, the new improved faba bean variety. The new improved variety is considered suitable across a range environment and it is tolerant to drought and decreased general length of the rainy season. The improved variety of faba bean has a life cycle of 5 years. The implementation and maintenance of a new improved variety of faba bean require about 162% and 206% more capital for installation and maintenance respectively when compared to what is required in BAU (Table 3). There was a 29% increase in the operating costs for the improved variety of faba bean seeds when compared with BAU. The main benefit associated with the use of improved faba bean seeds, therefore, emanated from increased yield per hectare (Figure 11). Compared to the BAU, the yield per hectare for the improved variety of faba bean seeds increased by about 81% (Figure 11).

The NPV associated with the new improved variety of faba bean seeds was US$ 2,366 per hectare (Table 3) with an IRR of about 62% which is significantly higher than the prevailing discount rate of 12%. Investing in an improved variety of faba bean seeds had a payback period of 1 year (Table 4), meaning that the use of an improved variety faba bean seeds is potentially appealing to farmers because of the short payback period. A longer payback act as a barrier for adoption and scaling up of innovations.

Risk assessment modeling using Monte Carlo simulation (n=10000 simulations) showed that use of improved variety of faba bean seeds has moderate risk as summarized in column 6 in Table 4. The results illustrate that the risk associated with implementing the use of improved faba bean seeds given the characteristics of the cumulative density function of expressing the probability of the NPV of being less than or equal to the costs of adopting this innovation (i.e. implementation, maintenance and operation costs) is moderate (12%) (Table 4).

The use of an improved variety of faba bean seeds is therefore profitable and have moderate financial risk, meaning that if farmers invest in this innovation, out of every 1000 farmers, 120 of them may end up getting unprofitable results in any given year. This result suggests that the use of an improved faba bean variety constitutes one of the promising innovations in Ethiopia. Besides, these results also underscore the fact that the use of a new improved variety of faba bean seeds has potential barriers to its adoption and scaling up due to the high implementation and maintenance costs. This means that for farmers to adopt and implement this practice, there is a need for sufficient financial support at least for one year or until when they start to achieve a break-even point.

Table 3. Summary Information on Installation cost for business as usual (BAU) and the new improved seed variety in the faba bean value chain in Ethiopia

	INSTALLATION COSTS			MAINTENANCE COSTS			OPERATION COSTS		
	BUSINESS AS USUAL	IMPROVED SEED VARIETY	% CHANGE IN COST	BUSINESS AS USUAL	IMPROVED SEED VARIETY	% CHANGE IN COST	BUSINESS AS USUAL	IMPROVED SEED VARIETY	% CHANGE IN COST
Cost in US$/ha	321	839	+162	872	2668	+206	298	386	+29

Figure 11. Yield for Business as usual versus the innovation (use of new improved faba bean seeds)

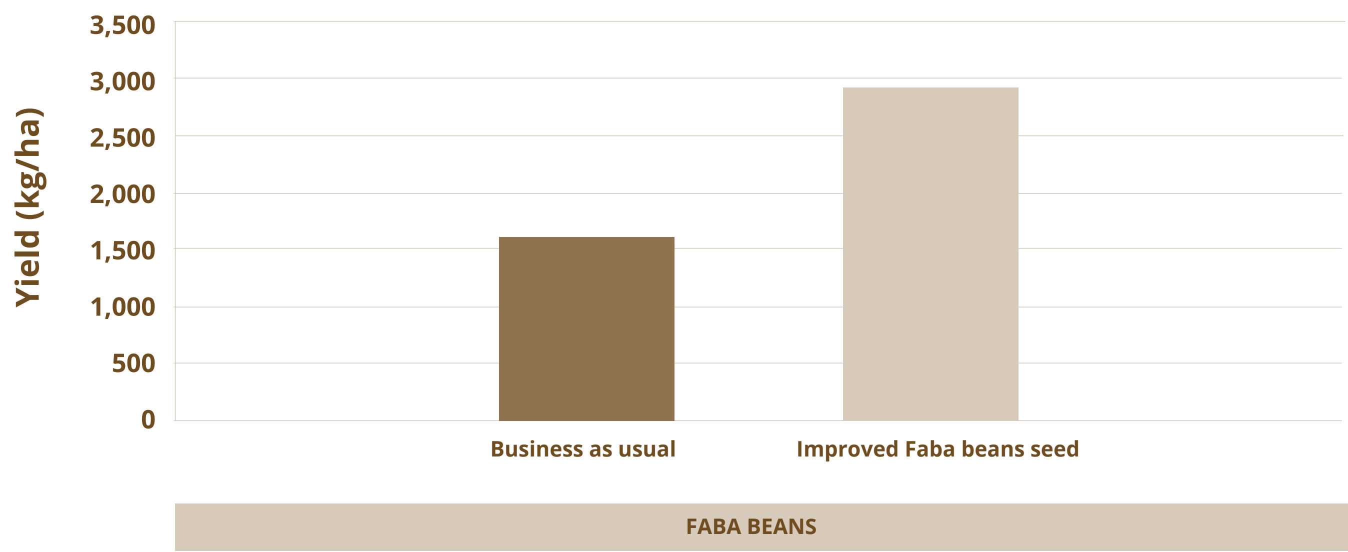


Table 4. Summary information on profitability associated with investing in improved variety of Faba bean seed in Ethiopia

VALUE CHAIN	INNOVATION	PROFITABILITY INDICATORS			
		NPV IN US$	IRR IN (%)	PAYBACK PERIOD (YEARS)	RISKINESS OF INVESTMENT
Faba bean	New improved seed variety	2,366	62% (>r)	1	This innovation has about a 12.5% probability of making unprofitable returns

NB: >r implies that the practice is privately profitable per hectare basis.

7. SYNTHESIS AND RECOMMENDATIONS

Historical data and future climate projections indicate that droughts, shorter growing seasons, heat stress, flash floods, and variable rain intensity are already affecting crop and livestock production in Arsi and will continue to do so. Climate change hazards coupled with sub-optimal use of inputs, low mechanization, limited access to quality seeds, poor agricultural practices, and underdeveloped markets together result in low agricultural production. These hazards put farmers at heightened risk, in part because they are among the most vulnerable groups due to poverty rate and high dependence on rainfed agriculture.

This profile identified several promising adaptation practices with a potential to enhance the resilience of farmers in Arsi who are faced with climatic hazards. Along the faba bean value chain, these practices include crop rotation and the use of an improved plough called a Berken Maresha. For wheat, auspicious strategies include the provision of extension services through a client-centered approach, the use of improved seeds, and rainwater storage. For honey, promising adaptation practices include agroforestry, integrated crop protection, reduced reduction pesticide use, the provision of extension services, and the construction of a honey accelerator platform.

CBA is very important for evaluating innovations, especially when investment decision needs to be made. Despite the strength and limitation (i.e., potential inaccuracies when identifying and quantifying costs and benefits for a given innovation) associated with CBA methodology, CBA is very critical for planning purposes, targeting future investment and also for informing challenges and barriers associate with scaling up of innovations. The use of improved faba bean seeds variety considered in the present analysis is a 'no-regret option', implying that it will yield economic benefits now and in the future and is, therefore, important for strengthening future household resilience. The use of improved faba bean seeds is profitable, has a high IRR and a short payback period, and this could explain why this innovation emerged as a strong choice for stakeholders during the prioritization process in Ethiopia. Despite the high implementation and maintenance costs, when the distribution of the NPV is considered, the use of a new improved variety of faba bean seeds has a moderate likelihood of being unprofitable, and hence makes an economic case for its scaling up. This is key, given that GIC is interested in identifying innovations that can produce desirable outcomes for a majority of smallholder farmers in Ethiopia.

Going forward, a variety of opportunities for collaboration, funding, and synergies exist for these practices (Table 5). Several organizations are well positioned to offer general support across all potential activities. For example, the Ethiopian government's Value Chain Roadmap for Pulses promises to boost production, increase market access, and raise farmers' incomes. The Climate-Resilient Green Economy Strategy attempts to address the effects of climate change holistically through all aspects of the economy. Several federal institutions are mandated to deal with climate change adaptation and mitigation with the country such as the Ministry of Environment, Forest and Climate Change (MEFCC), the Ministry of Agriculture and Natural Resources (MoANR), the Agricultural Transformation Agency, the Ethiopian Institute of Agricultural Research, and the universities. The latter two together constitute the National Agricultural Research System (NARS). Research institutions that collaborate with the NARS include the Consultative Group on International Agricultural Research (CGIAR) Centers, the International Maize and Wheat Improvement Center, the World Agroforestry Centre, the International Crops Research Institute for the Semi-Arid Tropics, the International Livestock Research Institute, CIAT, the International Water Management Institute, the International Center for Agriculture Research in the Dry Areas (ICARDA), and the International Centre of Insect Physiology and Ecology (ICIPE).

Further, several barriers challenge the general implementation of climate-aware policy in Ethiopia. Institutional capacity and continued government support in terms of financial support are needed, along with gender-inclusive policies and strategies, collaborative work with developmental partners, investments in improving infrastructure, and broader access to essential goods and services.

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Table 5. Practice-group specific potential strategies and considerations for advancing CSA at scale

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	FUNDING	SYNERGIES
Crop rotation		**Farm level barriers:**[**] • Knowledge gaps • Financial constraints **Institutional barriers:** • Weak land tenure security • Small plot sizes • Inconsistent extension services • Poor financial service availability • Widespread use of mono-cropping	• Good potential for green blended finance • Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Improved soil fertility improves harvest yields, water retention, and climate resiliency. This in turn supports improved water management and robust, stable markets
Land management	• Ethiopian government, e.g. through its Agricultural Policy Investment Framework (PIF) and Climate-Resilient Green Economy Strategy	**Farm level barriers:**[**] • Knowledge gaps • Financial constraints **Institutional barriers:** • Weak land tenure security • Small plot sizes • Inconsistent extension services • Low energy access creates competing priorities for woody biomass • Labor shortages[**] • Suboptimal mechanization levels • Low adoption of soil conservation practices • Poor financial service availability • Weak finance services	• Good potential for green blended finance • Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Improved soil fertility improves harvest yields, water retention, and climate resiliency. This in turn supports improved water management and robust, stable markets
Manure management		**Farm level barriers:**[**] • Labor-intensive, particularly in extensive systems **Institutional barriers:** • Suboptimal mechanization levels • Poor energy access creates competing needs for organic residues[**]	• Good potential for green blended finance • Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Improved soil fertility improves harvest yields, water retention, and climate resiliency. This in turn supports improved water management and robust, stable markets
Integrated pest management		**Farm level barriers:**[**] • Knowledge gaps • Financial constraints **Institutional barriers:** • Inconsistent extension services • Poor financial service availability • Inconsistent input availability[**]	• Good potential for green blended finance • Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Supports both productivity and environmental/land restoration goals
Harvesting technique		**Farm level barriers:**[**] • Knowledge gaps • Financial constraints **Institutional barriers:** • Inconsistent extension services	• Primarily publicly funded through extension support, with possible private extension support options	• Optimized harvesting enables improved processing and storage

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	FUNDING	SYNERGIES
Improved processing	• Ethiopian government, e.g. through its Value Chain Roadmap for Pulses	**Farm level barriers:**** • Knowledge gaps • Financial constraints **Institutional barriers:** • Suboptimal infrastructure • Lack of production contracts impacts opportunities for economies of scale in processing**	• High potential for private sector investing	• Best processing practices reduce losses in storage and in transport to market, thus stabilizing supplies.
Production best practices	• Agricultural Transformation Agency • International Center for Agriculture Research in the Dry Areas (ICARDA) • National Agricultural Research System (NARS) • United States Agency for International Development (USAID)	**Farm level barriers:**** • Knowledge gaps • Financial constraints **Institutional barriers:** • Inconsistent extension services • Weak land tenure • Low energy access • Labor shortages** • Suboptimal mechanization levels • Weak finance services • Need for improved inputs, e.g. modern beehives	• Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity.	• Supports climate-resiliency and yields, thus improving market stability
Storage and Post-harvest	• Agricultural Transformation Agency	**Farm level barriers:**** • Capital constraints • Knowledge gaps **Institutional barriers:** • Suboptimal infrastructure, including inadequate access to good roads, cold storage, warehouses, and other conservation technologies	• High potential for private sectoinvesting	• Reduces losses, thus increasing profits and supporting markets stability, particularly inter-seasonally

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	FUNDING	SYNERGIES
Variety improvement	• International Center for Agriculture Research in the Dry Areas (ICARDA) • National Agricultural Research System (NARS) • United States Agency for International Development (USAID) • Food and Agriculture Organization of the United Nations (FAO)	**Farm level barriers:** • Financial constraints • Considerable capital required • Some financial risk involved in switching varieties **Institutional barriers:** • Inadequate access to inputs • Inconsistent distribution networks • Centralized seed system in need of reform, leading to delays • Domination of expensive, imported varieties** • Dearth of human resources**	• International research funding offers robust support; diversification toward local and culturally important crops needed	• Climate-resilient varieties help stabilize harvest quantities, thus supporting stable markets
Water management		**Farm level barriers:**** • Financial constraints • Knowledge gaps • Labor shortages • **Institutional barriers:** • Lack of infrastructure • Weak financial services • Suboptimal mechanization levels • Low adaptation of water conservation practices	• Public and private interests with good blended finance potential	• Effective water management reduces erosion and flooding to support productivity and land restoration efforts

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	FUNDING	SYNERGIES
Climate services	• Ethiopian government, e.g. through its Growth and Transformation Plan (2016-2020) • International Centre of Insect Physiology and Ecology (ICIPE), e.g. through the More Young Entrepreneurs in Silk and Honey Project • Farm Africa • The Netherlands Development Organization (SNV)	**Farm level barriers:**** • Understanding how to apply climate information • Finance constraints **Institutional barriers:**** • Institutional capacity for provision of services • Leveraging appropriate channels to reach all farmers • Production of sufficient data and translation of the same to practical advisories	• Public and private interests with good blended finance potential	• Supports efficiency and planning in input provision, production, postharvest transport and processing, and marketing
Marketing	• Ethiopian federal government, e.g. through its Value Chain Roadmap for Pulses and Growth and Transformation Plan (2016-2020) • Agricultural Transformation Agency • International Centre of Insect Physiology and Ecology (ICIPE), e.g. through the More Young Entrepreneurs in Silk and Honey Project	**Farm level barriers:** • Poor transport connectivity to marketplaces **Institutional barriers:** • Insufficient policy framework • Lack of long-term production contracts • Underdevelopment of apiculture as a business venture • Underdeveloped markets, involving poor price channels and a lack of quality and quantity standards	• High potential for private sector investing	• Reliable storage and processing systems support market stability and consumer confidence • Organic inputs support niche marketing

** based on literature

However, to foster the adoption of the above-mentioned practices and the achievement of a food-secure Ethiopia, the federal government needs to create an enabling environment to transform the agricultural sector. This can be done by establishing gender-inclusive policies and strategies, through collaborative work with developmental partners, by investing to improve infrastructure, and by broadening access to essential goods and services. Additionally, there is a need to better farmers' education through improved extension services that can be modeled on GIC work in Arsi using the client-centered extension approach and farm service centers.

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